Abstract

Objective: High negative affect, low positive affect, and low cognitive functioning are depression-related states that may be particularly relevant to females who smoke cigarettes and may be more prominent following overnight tobacco abstinence. This study aimed to assess relations between depression symptom levels and negative affect, positive affect, and cognitive functioning in premenopausal females who smoke. **Methods:** Premenopausal females who smoke daily with low (n=66) or elevated (n=33) baseline depression symptoms completed subjective ratings of negative affect, positive affect, and cognitive functioning pre-first cigarette (i.e., after overnight tobacco abstinence) and at random prompts throughout the day via ecological momentary assessment (EMA) for 35 days. **Results:** Participants with elevated depression symptoms reported overall higher negative affect (p=.01). Positive affect was significantly lower prior to the first cigarette of the day (p<.001), but did not significantly differ between depression symptom groups. Subjective cognitive functioning was significantly lower pre-first cigarette of the day (p<.001). There was a significant depression symptom × prompt type interaction for subjective cognitive functioning (p=.01). Subjective cognitive functioning did not significantly differ by depression symptom group pre-first cigarette of the day but was significantly different at random prompts throughout the day. **Conclusions:** As participants smoked as usual, findings identify naturalistic factors which may influence smoking behavior among premenopausal females who smoke with elevated depression symptoms.

Keywords: females who smoke, depression symptoms, positive affect, negative affect, cognitive functioning

Public health statement: By showing that depressive symptoms relate to affect and subjective cognitive functioning during naturalistic smoking among females who smoke daily, this study highlights potential factors that may help guide smoking cessation induction strategies for females with elevated depressive symptoms.

Introduction

Individuals with elevated depression symptoms are more likely to initiate and escalate cigarette smoking and may have a harder time quitting smoking (Kinnunen et al., 1996; Leventhal et al., 2008). Furthermore, depressive episodes and symptoms are more common in females compared to males (Abate, 2013; Bebbington et al., 2003; Cyranowski et al., 2000), and females (vs. males) may show stronger associations between syndromal and subsyndromal depression and smoking behavior (Husky et al., 2008; Paivarinta et al., 1999). Hence, it is imperative to understand associations between depression symptoms and smoking-related factors in the everyday environment among females who smoke in order to identify processes that may contribute to maintaining smoking behavior. More specifically, incentive learning theory proposes that people who smoke with elevated depression symptoms experience greater smoking reinforcement and urge to smoke during three adverse motivational states: high negative affect, low positive affect, and low cognitive functioning (Mathew et al., 2017). Thus, understanding how these three depression-related states in particular associate with everyday smoking behavior may be helpful in evidencing emotional and cognitive aspects that may motivate certain individuals who smoke (e.g., females with elevated depression symptoms) to continue smoking.

A robust literature evidences a relationship between negative affect and smoking and suggests that this relationship may differ by depression symptom levels. Survey-based studies have found that people who smoke with elevated depression symptoms (compared to those with low depression symptoms) report greater expectations that smoking relieves negative affect and may be more likely to smoke in response to negative affect (Kinnunen et al., 1996; Leventhal et al., 2008). In addition, laboratory and daily diary studies have found that people who smoke with elevated depression symptoms (compared to those with low depression symptoms) report greater

negative affect following experimentally induced acute tobacco abstinence (Leventhal et al., 2013) and during an unaided smoking cessation attempt (Copeland et al., 2009).

Studies on affect and smoking support the utility in differentiating between positive and negative affect. Laboratory-based research has evidenced that positive affect decreases during acute tobacco abstinence (Leventhal et al., 2013), and that people who smoke and report low (vs. high) baseline positive affect experience greater cigarette abstinence-induced decreases in positive affect (Cook et al., 2007; Leventhal et al., 2013). Furthermore, smoking has been shown to increase positive affect to a greater extent in those with elevated depression symptoms compared to low depression symptoms (Audrain-McGovern et al., 2014).

Cognitive functioning, especially across the domains of complex attention and executive function (e.g., decision-making, working memory), is a well-studied smoking outcome. A meta-analysis of 42 acute abstinence and 13 cessation studies, found that people who smoke going through acute nicotine abstinence showed reduced cognitive functioning (i.e., higher delay discounting, lower response inhibition, impaired arithmetic, recognition memory performance) compared to non-abstinent individuals (Grabski et al., 2016). Other prior work has shown that nicotine administration following acute cigarette abstinence may improve cognitive functioning (Campos et al., 2016; Levin et al., 2006; Powell et al., 2004; Valentine & Sofuoglu, 2018). Laboratory-based research also has evidenced greater declines in cognitive functioning following overnight tobacco abstinence in people who smoke with a history of major depression and current depression symptoms compared to those with no history and current symptoms (Ashare et al., 2014). Notably, while much of the literature on cognitive functioning among people who smoke has focused on objective measurements (e.g., Stroop Task), the current study utilizes a subjective measurement of cognitive functioning (based on the domains of complex attention and

executive function). Subjective measurement of cognitive functioning is also important to investigate given the largely subjective nature of the cognitive symptoms of depression.

Most prior work that examined associations of elevated depression symptoms with affect and cognitive functioning used cross-sectional survey and laboratory-based methods, which have limited ecological validity. Studies that use ecological momentary assessment (EMA) may overcome some of these limitations by collecting repeated measurements of experiences and behaviors throughout the day in individuals' natural environments (Shiffman et al., 2008). One study utilized EMA in investigating baseline depression symptom levels in relation to affective reactivity to stressful events, and found that people who smoke with elevated depression symptoms (compared to those with low depression symptoms) experience prolonged post-stress increases in negative affect and decreases in positive affect during a cessation attempt (Minami et al., 2017). Another EMA cessation study found that elevated depression symptoms were associated with overall greater negative affect, but not with physical withdrawal symptoms or relapse outcomes (Brodbeck et al., 2014). Though they provide valuable information, findings from these prior EMA studies focused on cessation. As many individuals who smoke are not willing or ready to quit smoking (Babb et al., 2017) and factors that predict making a quit attempt differ from those that predict smoking cessation relapse (Klemperer et al., 2020), it is also important to investigate associations of depression symptom levels with affect and subjective cognitive functioning while individuals are smoking as usual in order to understand how these associations occur under naturalistic patterns of abstinence (i.e., with no instructions to abstain or intent to quit smoking). As such, the use of EMA to assess associations of depression symptom levels with affect and subjective cognitive function while smoking as usual can increase

the generalizability of findings across naturally occurring contexts and situations and can provide additional information about the processes involved in smoking maintenance.

The current report is a secondary analysis of survey and EMA data from a larger study investigating associations of ovarian hormones with smoking behavior in non-treatment-seeking premenopausal females who smoke daily. Premenopausal females who smoke daily reported baseline depression symptoms and then completed up to 35 days of EMA while smoking as usual. During EMA, participants completed subjective ratings of negative affect, positive affect, and subjective cognitive functioning prior to the first cigarette of the day and at random times throughout the day. The aim of this study was to investigate the main and interactive associations of depression symptom levels and overnight abstinence prior to the first cigarette of the day with negative affect, positive affect, and subjective cognitive functioning. We hypothesized that 1) females who smoke would report greater negative affect, lower positive affect, and lower subjective cognitive functioning prior to the first cigarette of the day compared to other times throughout the day; and 2) across all prompts, females who smoke with elevated depression symptoms would report overall greater negative affect, lower positive affect, and lower subjective cognitive functioning compared to females who smoke with low depression symptoms. As prior studies suggest that people who smoke with elevated depression symptoms may experience pronounced experimentally induced and cessation-related abstinence effects (Ashare et al., 2014; Brodbeck et al., 2014; Copeland et al., 2009; Leventhal et al., 2013), we also hypothesized that greater negative affect, lower positive affect, and lower subjective cognitive functioning would be particularly pronounced among females who smoke with

elevated depression symptoms (vs. those with low depression symptoms) prior to the first cigarette of the day compared to at random times throughout the day.

Methods

Participants

Participants were recruited from the Los Angeles metropolitan area (California, US) via online and paper advertisements for a paid research study from December 2015 to October 2017. All participants provided informed consent, and the University of Southern California Institutional Review Board approved all procedures.

Inclusion criteria required participants to (a) be 18-40 years of age, (b) be a female with self-reported regular menstrual cycles lasting 24-35 days in the past 3 months, (c) be a person who smokes regularly (≥8 cigarettes/day) for at least the past year and have a baseline breath carbon monoxide (CO) level of >9 ppm, (d) have self-reported normal eyesight, (e) be fluent in English, and (f) own a smartphone. Exclusion criteria included (a) current use of nicotine replacement therapy or psychiatric medication (e.g., Bupropion/Wellbutrin, Forfivo, Zyban, or Chantix) implicated in smoking cessation to standardize for the effect of medication on withdrawal and smoking behavior, (b) regular use of any other non-cigarette tobacco products (including e-cigarettes or vaping devices, cigars, cigarillos, chewing tobacco, snus, or hookah), (c) past 3-month use of hormonal medication including birth control or intent to start hormonal medication in the next 35 days, (d) history of hysterectomy or intent to obtain hysterectomy in the next 35 days, (e) a desire to quit or to substantially reduce smoking in the next 35 days, and (f) pregnancy or breastfeeding in the past 6 months or intent to get pregnant in the next 35 days.

Procedure

Following an initial phone-based eligibility screen, participants attended an in-person baseline session including informed consent, additional eligibility screening, and EMA data download and training. At the baseline session, CO levels were measured using Vitalograph carbon monoxide monitors to verify self-reported smoking status. Eligible participants downloaded the commercially available LifeData app (www.lifedatacorp.com) onto their own smart devices and were trained on EMA protocols. Participants were then enrolled for 35 days of EMA including completing: 1) event-contingent prompts indicating they are about to smoke the first cigarette of the day or another cigarette; 2) event-contingent prompts upon completion of smoking the first cigarette of the day; 3) four random signal-contingent prompts delivered to their phone (with at least 90 minutes between them); 4) one fixed-interval prompt completed upon waking up for the day; and 5) one fixed-interval prompt prior to going to bed. Participants were contacted approximately twice per week throughout participation to review study compliance and were paid at the end of every week they were enrolled in the study. Participants were compensated for the baseline session and weekly survey compensation was based on survey compliance (i.e., ≥ 85%, 65% to 84%, and ≤ 65%). Participants earned a bonus for each week with 100% compliance. In total, participants were compensated up to $515 for completing the entire study.

Measures

Baseline session measures

Baseline session measures were administered using REDCap electronic data capture tools hosted at University of Southern California (Harris et al., 2009). An author-constructed questionnaire assessed demographics (e.g., age, race, ethnicity, education), and smoking history (e.g., cigarettes per day, years of regular smoking). Participants completed a check-all-that-apply

question for race: *American Indian or Alaskan Native*, *Asian (including the Philippine Islands, Southeast Asia, and India*), *Black or African American*, *Middle Eastern*, *Pacific Islander (including Hawaii*), *White*, *Other;* and selected their ethnicity as *Hispanic or Latino* or *Not Hispanic or Latino*. Individuals that checked more than one race were coded as multi-racial. Participants were classified into racial/ethnic groups based on their responses to both questions (e.g., Non-Hispanic White, Non-Hispanic Black, Hispanic, any race). Race/ethnicity was included as a planned covariate as a prior study found sex differences in negative affect among non-Hispanic White individuals but not among non-Hispanic African American individuals (Pang et al., 2018). Education was included as a planned covariate as education has been shown to influence subjective cognitive functioning (Alley et al., 2007; Guerra-Carrillo et al., 2017; Lee et al., 2003).

The Fagerström Test for Cigarette Dependence (FTCD) is a 6-item self-report measure of cigarette dependence severity (range 0-10 with higher scores indicating greater dependence severity) (Fagerstrom, 2012; Fagerström, 2003) and was included as a planned covariate given the association between cigarette dependence and cigarette abstinence effects (Baker et al., 2012; Ben Taleb et al., 2016; Fagerström, 2003; Koob, 2006; Piper et al., 2006; Shiffman et al., 2004).

The Center for Epidemiologic Studies Depression Scale (CES-D) was used to measure depression symptoms (Radloff, 1977). This 20-item self-report scale measures the frequency of past week depression symptoms (e.g., depressed mood, feelings of guilt and worthlessness, loss of interest, psychomotor retardation, sleep disturbance) on 4-point Likert items with responses ranging from 0 (*Rarely or none of the time, 0-1 days*) to 3 (*Most or all of the time, 5-7 days*), which are then summed to determine a total score ranging from 0 to 60 with higher scores indicating greater depression symptoms. Participants with a CES-D score $\geq$ 20 were classified as

having an elevated level of depression symptoms (=1) and those with CES-D score <20 were classified as having a low level of depression symptoms (=0). In a meta-analysis that pooled studies which used the CES-D to screen for major depression, the best trade-off between sensitivity (83%) and specificity (78%) was evidenced by this particular cutoff score (Vilagut et al., 2016).

EMA measures

Following an indication they were about to smoke the first cigarette of the day and at random signal-contingent prompts, participants rated the extent to which they experienced past 30-minute positive affect (4 items: happy, content, relaxed, cheerful) and negative affect (4 items: tense or anxious, sad or blue, irritable or easily angered, unable to cope or overwhelmed by ordinary demands) based on the Positive Affect and Negative Affect Schedule (Watson et al., 1988) and the Premenstrual Assessment Form (Allen et al., 1991). We included repeated assessments of affect throughout the day as a coordinated analysis of variance study found considerable within-person variance occurs within days (Scott et al., 2018).

At these same prompts, participants also rated current subjective cognitive functioning (4 items: I feel alert; I have been able to concentrate well; I work efficiently; I feel engaged/interested; Houtveen & Sorbi, 2013). Responses were recorded on a scale ranging from 1 (*not at all*) to 6 (*extremely*) and a mean score was computed for variable at each time point. To reduce participant burden, subjective cognitive functioning was only assessed at two of the four random signal-contingent prompts and subsequently had fewer datapoints for analyses.

Data Analysis

Preliminary data analyses assessed EMA survey compliance and patterns of missing data. Survey compliance was calculated separately for the event-contingent pre-first cigarette and the

random signal-contingent prompts and represents the percentage of surveys that were responded to divided by the total number of surveys to be delivered based on the study protocol (i.e., 34 total first cigarette prompts/participant, 136 random prompts/participant). Patterns of missing data were investigated by assessing associations of survey compliance with demographics, baseline smoking characteristics, and key variables. To investigate potential selection bias, we compared sample descriptives in completers and non-completers using independent samples t-tests for continuous variables and chi-square tests for categorical variables. Depression symptom group differences in sample characteristics were assessed using independent samples t-tests for continuous variables and chi-square tests for categorical variables. Sample characteristics that were significantly different by depression symptom group were included as covariates in the final model.

Primary aims were evaluated using multilevel linear models, which account for nesting of the data within participants. Model 1 tested the main effects of baseline depression symptoms (low vs. elevated depression symptoms) and EMA prompt type (pre-first cigarette vs. random prompts) on negative affect, positive affect, and subjective cognitive functioning. Model 2 included the interaction of baseline depression symptoms and EMA prompt type. Significant interactions were examined using post-hoc pairwise comparisons of estimated marginal means derived from the multilevel models. Models controlled for the following covariates: cigarette dependence, race/ethnicity (Binary: Non-Hispanic White vs. Other), education (Binary: Less than college vs. At least some college), and age (based on preliminary analyses, see Results). Cigarette dependence and age were grand mean centered (i.e., individual score minus average score from the full sample). Effect sizes were calculated following Xu (2003) operationalization

of R^2 as the residual variance of the model compared to the residual variance of the intercept-only null model and are shown in Table 2. Analyses were conducted in SPSS v. 25.

Results

Sample Characteristics

Of the 101 participants deemed eligible at baseline, one participant was removed from analyses due to self-disclosure at the debrief of psychotic break during EMA data collection and one participant was removed from analyses due to becoming pregnant during EMA data collection, leaving an analytic sample of 99. Of the 99 participants included in the analytic sample, 76 completed all 35 days of EMA data collection (i.e., completers), and 23 were dropped from the study and did not complete all 35 days of EMA data collection (i.e., non-completers). Of the 23 non-completers, 12 participants were dropped due to low EMA compliance (<65% for a week and a half); 7 were dropped due to technical issues with their phone (e.g., excessive survey glitches, data not being received on the EMA platform); and 4 were dropped due to no longer being interested. Analyses included data from both completers and non-completers. Completers vs. non-completers did not significantly differ by age, education, race/ethnicity, baseline cigarettes per day, years of regular smoking, or cigarette dependence severity (*p*s>.05). Non-completers had significantly lower pre-first cigarette prompt compliance and random prompt compliance (*ps*<.001).

Total sample demographics and smoking characteristics, overall and by depression symptom group, are reported in Table 1. Ninety-eight participants self-identified their gender as female, and one participant self-identified their gender as non-binary. There were no significant differences between depression symptom groups (elevated depression symptoms *n*=33, low depression symptoms *n*=66) for race/ethnicity, baseline cigarettes per day, years of regular

smoking, cigarette dependence severity, or pre-first cigarette and random prompt compliance (Table 1). The low depression symptoms group was significantly younger on average and a higher proportion had attained 'at least some college' compared to the elevated depression symptoms group (Table 1). During EMA, low depression level participants reported an average negative affect of 1.90 (*SD*=1.01), positive affect 3.59 (*SD*=1.34), and subjective cognitive functioning 3.52 (*SD*=1.31). During EMA, high depression level participants reported negative affect of 2.29 (*SD*=1.23), positive affect 3.26 (*SD*=1.30), and subjective cognitive functioning 3.40 (*SD*=1.24).

EMA Study Compliance and Missing Data

Day 1 EMA data were used to allow participants to practice responding to prompts and was excluded from analyses, leaving up to 34 days of data for each participant. Participants completed an average of 28.80 study days (*SD*=9.97). Participants responded to a total of 2,590 (76.95%) event-contingent pre-first cigarette prompts and 9,288 (68.98%) random signal-contingent prompts. Pearson's correlations revealed a strong correlation of event-contingent pre-first cigarette prompt compliance and random signal-contingent prompt compliance (r=.97, p<.001). Event-contingent pre-first cigarette and random signal-contingent compliance did not correlate with age, education, cigarette dependence, baseline cigarettes per day, and years of regular smoking. One-way ANOVAs showed no significant differences in event-contingent pre-first cigarette and random signal-contingent compliance by race/ethnicity.

To reduce the likelihood that an event-contingent pre-first cigarette prompt was completed after normal smoking for the day has started, we removed event-contingent pre-first cigarette prompts that followed an event-contingent post-first cigarette prompt or had 'another cigarette' logged between that day's wake time and the event-contingent pre-first cigarette

prompt (n=140). To verify that the random signal-contingent prompts are not measuring overnight abstinence effects, random signal-contingent prompts that occurred prior to a participant logging a cigarette that day (n=1090) were removed. Analyses including all random signal-contingent prompts did not significantly change the results (results not reported here).

Negative Affect

Females with low depression symptoms reported overall lower negative affect compared to females with elevated depression symptoms (p=.01; Table 2). Negative affect did not significantly differ prior to the first cigarette of the day compared to at random prompts throughout the day (p=.06; Table 2). There was not a significant depression symptom × prompt interaction for negative affect (p=.35, Table 2).

Positive Affect

Depression symptom groups did not significantly differ on overall positive affect (p=.06; Table 2). Positive affect was significantly lower prior to the first cigarette of the day compared to at random prompts throughout the day (p<.001; Table 2). There was not a significant depression symptom × prompt interaction for positive affect (p=.79; Table 2).

Subjective Cognitive Functioning

Depression symptom groups did not significantly differ on overall subjective cognitive functioning (p=.07; Table 2). Subjective cognitive functioning was lower prior to the first cigarette of the day in comparison to at random prompts throughout the day (p<.001; Table 2). There was a significant depression symptom × prompt interaction for subjective cognitive functioning (p=.01; Table 2). Pairwise comparisons showed that subjective cognitive functioning did not significantly differ between depression symptom groups prior to the first cigarette of the day (p=.16) but was significantly different at random prompts (p=.03) throughout the day with

lower subjective cognitive functioning reported by those with elevated depression compared to those with low depression (Figure 1).

Discussion

To the best of our knowledge, this was the first study to examine the relationship of depression symptoms with affect and subjective cognitive functioning in premenopausal females who were smoking as usual in a naturalistic setting. Consistent with our hypotheses, females who smoke with elevated depression symptoms reported overall higher negative affect compared to those with low depression symptoms. This finding is in accord with prior research that shows people who smoke with elevated depression symptoms experience more intense negative affect (Strong et al., 2009) and greater negative affect in response to negative mood induction while smoking as usual (Cook et al., 2017){Cook, 2017 #6}. In contrast with our hypotheses, the association of depression symptom level with negative affect did not depend on whether assessment occurred before or after the first cigarette of the day. Prior studies have found that people who smoke with elevated depression symptoms experience greater negative affect following cigarette abstinence (Audrain-McGovern et al., 2014; Leventhal et al., 2013) and prolonged negative affect following naturalistic stressors during a quit attempt (Minami et al., 2017). As the current study allowed participants to smoke as usual, these findings expand prior studies by suggesting that females who smoke with elevated depression symptoms may experience overall elevated negative affect, but this is not exacerbated during naturalistic periods of overnight cigarette abstinence (i.e., prior to smoking the first cigarette of the day).

Contrary to our hypotheses, results were not statistically significant as to whether females who smoke with elevated depression symptoms (vs. those with low depression symptoms) have lower overall positive affect, and the association of depression symptom level with positive affect

did not depend on whether the assessment occurred prior to or after the first cigarette of the day. One possible reason for why we did not find a statistically significant relationship is not having distinguished between anhedonia and depression symptoms more broadly. For example, one study found that people who smoke who were specifically anhedonic reported greater abstinence-induced declines in positive affective states, whereas people who smoke who were more generally anxious or depressed reported greater abstinence-induced increases in negative affective states (Leventhal et al., 2013). Thus, as studies continue to highlight the need to distinguish between the roles of low positive affect and high negative affect in smoking, the results of this study also suggest that it may be important to consider how chronic low positive affect and high negative affect might differentially associate with state positive and negative affect. Consistent with our hypotheses, positive affect was lower prior to the first cigarette of the day compared to at random prompts throughout the day. This finding is in agreement with prior research indicating that positive affect decreases during acute tobacco abstinence (Leventhal et al., 2013; Minami et al., 2017).

We also found that subjective cognitive functioning was lower prior to the first cigarette of the day. This finding is similar to previous studies that have shown cognitive functioning is diminished during tobacco abstinence (Gilbert et al., 2004), and improved by nicotine administration following acute cigarette abstinence (Campos et al., 2016; Levin et al., 2006; Powell et al., 2004; Valentine & Sofuoglu, 2018). Contrary to our hypotheses, results were not statistically significant as to whether females who smoke with elevated depression symptoms (vs. those with low depression symptoms) have lower overall subjective cognitive functioning. Further contrary to our hypotheses, females who smoke with elevated depression symptoms (vs. those with low depression symptoms) did not have significantly different subjective cognitive

functioning prior to the first cigarette of the day; however, they did have significantly lower subjective cognitive functioning at random prompts throughout the day. In a prior systematic review on smoking and depression comorbidity, it was proposed that diminished cognitive functioning in depression is comparable to diminished cognitive functioning caused by tobacco abstinence (Mathew et al., 2017). Thus, it is possible that the benefits of smoking on subjective cognitive functioning are greater for females who smoke with low depression symptoms compared to those with elevated depression symptoms.

The results of the study must be considered within the context of its limitations. As the study was conducted in a non-treatment seeking sample of premenopausal females who smoke who were instructed to smoke as usual, the results of this study may not be generalizable to treatment-seeking samples, or postmenopausal females who smoke. High and low depression symptoms groups were classified using dichotomized CES-D scores with a cut-off score of 20, as opposed to a clinical diagnosis, and we excluded participants on medications for smoking cessation that are also used for depression (e.g., bupropion). Thus, results may not be generalizable to those receiving pharmacological treatment for depression. The study also did not compare male versus female outcomes. Prior studies have found higher trait/state negative affect and greater negative affective symptoms accompanying depression in females compared to males (Khesht-Masjedi et al., 2017; Langvik et al., 2016), and several other studies reported higher trait/state anhedonia in males who smoke (Cook et al., 2015; Cook et al., 2007; Guillot et al., 2017; Leventhal et al., 2014; Powers et al., 2017) relative to their female counterparts. Given sex/gender differential patterns in depressive symptomology, it is possible that the results of this study will not generalize to males who smoke, and it will be important for future studies to consider sex/gender differences in associations of depression symptoms levels with state affect

during naturalistic smoking. Despite not addressing sex/gender differences, these findings provide important information about how depression symptoms may influence naturalistic patterns of affect and subjective cognitive functioning in females who smoke. Additionally, this study only used self-report measures of affect and cognitive functioning and compared event-contingent prompts to random signal-contingent prompts. Therefore, it is possible that there are systematic biases in completing the reports and that findings are more applicable to self-reported symptoms and states related to depression which may have been impacted to some extent by common-method variance. Moreover, ratings of subjective cognitive functioning at the event-contingent prompt prior to the first cigarette of the day may be affected by fatigue following overnight abstinence. Therefore, the effects of fatigue on cognitive functioning will be important to investigate in future studies. Lastly, while tracking of cigarette smoking as a part of the study procedure may have prompted some individuals to cut down on smoking, we did not biochemically confirm smoking status at the end of the data collection period.

Despite these limitations, this study contributes to the literature on the relationship of depression symptoms with affect and subjective cognitive functioning during naturalistic patterns of smoking in premenopausal females who smoke. These findings importantly show that females who smoke with elevated depression symptoms experience increased negative affect throughout the day, but no significant differences in positive affect. As studies suggest that negative affect may be especially relevant to females who smoke (Faulkner et al., 2018; Pang & Leventhal, 2013; Xu et al., 2008), these findings emphasize the importance of addressing negative affect as part of positive behavioral change in females who smoke in general, and in females who smoke with elevated depression symptoms in particular. These findings additionally highlight that differentiating between positive and negative affect may be important in understanding how

associations between affect and smoking may differ by levels of depression symptoms. The current finding that subjective cognitive functioning was lower at random prompts throughout the day in females who smoke with elevated depression symptoms evidences that females who smoke with elevated depression symptoms may not benefit as much from the cognitive enhancing properties of nicotine following overnight cigarette abstinence in comparison to females who smoke with low depression symptoms. This suggests that smoking cessation treatments for those with elevated depression symptoms may need to focus on attenuating diminished subjective cognitive functioning. As participants were smoking as usual, these findings are also important in identifying factors that may underlie motivation to smoke and how these may differ prior to smoking the first cigarette of the day (i.e., the longest period of abstinence usually faced by people who smoke who are not attempting to quit) versus at random prompts throughout the day. Thus, this study highlights the role of utilizing EMA methodology to investigate depression symptom levels and naturalistic smoking in relation to affect and subjective cognitive functioning, which may help guide cessation induction strategies in females who smoke with elevated depression symptoms. Due to the higher prevalence of depression, stronger association between depression and smoking, and poorer cessation outcomes for women (Husky et al., 2008; Paivarinta et al., 1999; Smith et al., 2016; Smith, Weinberger, et al., 2017; Smith, Zhang, et al., 2017), identifying how affect and subjective cognitive functioning relate to smoking in females, more specific smoking cessation treatments for females who smoke with elevated depression could potentially be developed.

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Table 1

Demographic and cigarette smoking characteristics for the total sample and by baseline depression symptoms (elevated versus low).

Variable	*Total*[a] *N (%) / M (SD)*	*Low Depression Symptoms*[a] *N (%) / M (SD)*	*Elevated Depression Symptoms*[a] *N (%) / M (SD)*	*Test of Difference p-value*[b]
Demographic Characteristics				
Age (years)	31.66 (5.63)	32.45 (5.79)	30.06 (4.98)	.045
Education				<.001
Less than college	22 (22.20%)	8 (12.10%)	14 (42.40%)	
At least some college	77 (77.80%)	58 (87.90%)	19 (57.60%)	
Race/Ethnicity				.34
Non-Hispanic White	30 (30.30%)	20 (30.30%)	10 (30.30%)	
Non-Hispanic Black or African American	31 (31.30%)	23 (34.80%)	8 (24.20%)	
Non-Hispanic Asian	8 (8.10%)	6 (9.10%)	2 (6.10%)	
Hispanic, any race	15 (15.20%)	10 (15.20%)	5 (15.20%)	
Multi-racial	11 (11.10%)	4 (6.10%)	7 (21.20%)	
Other	4 (4.00%)	3 (4.50%)	1 (3.00%)	
Cigarette Smoking Characteristics				
Baseline cigarettes per day	11.92 (4.42)	12.02 (4.51)	11.73 (4.30)	.76
Years of regular smoking	12.47 (6.32)	13.05 (6.61)	11.33 (5.62)	.21
FTCD[c]	4.69 (1.99)	4.73 (2.05)	4.61 (1.89)	.78
EMA Study Compliance[d]				
First Cigarette Prompt Compliance	76.95% (33.38%)	80.84% (31.45%)	69.16% (36.19%)	.12
Random Prompt Compliance	68.98% (30.61%)	72.11% (29.68%)	62.72% (31.93%)	.15

[a]Total (*N*=99), Low Depression Symptoms (*n*=66), Elevated Depression Symptoms (*n*=33). [b]Tests of differences in sample characteristics by group were conducted with independent samples t-tests for continuous variables and chi-squared tests for categorical variables.

[c]FTCD=Fagerström Test of Cigarette Dependence. [d]EMA compliance was the percentage of surveys that were responded to based on the total number of surveys in the study protocol (e.g., 34 total first cigarette prompts/participant, 136 random prompts/participant).

Table 2

Associations of depression symptom levels and cigarette prompts on affect and cognitive functioning: Mixed Models Analysis Results—Estimates of Fixed Effects

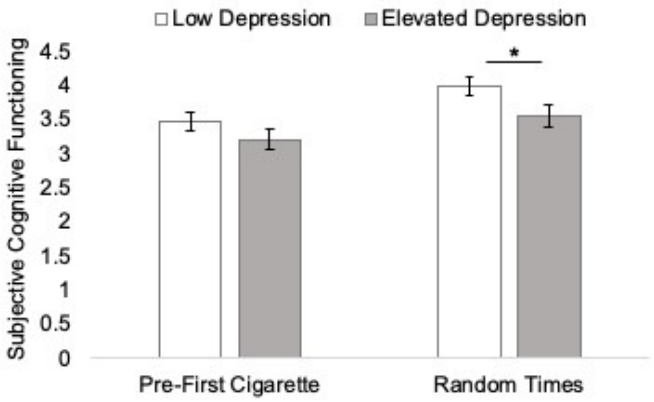
Variable	Negative Affect[a]				Positive Affect[b]				Subjective Cognitive Functioning[c]			
	Model 1[d]		Model 2[e]		Model 1[d]		Model 2[e]		Model 1[d]		Model 2[e]	
	Estimate (*SE*)	*p*	*Estimate* (*SE*)	*p*	*Estimate* (*SE*)	*p*	*Estimate* (*SE*)	*p*	*Estimate* (*SE*)	p	*Estimate* (*SE*)	*p*
Intercept	2.35 (0.17)	<.001	2.35 (0.17)	<.001	3.33 (0.20)	<.001	3.33 (0.20)	<.001	3.51 (0.18)	<.001	3.45 (0.19)	<.001
Age[f]	0.00 (0.01)	.72	0.00 (0.01)	.73	0.04 (0.02)	.04	0.04 (0.02)	.04	0.04 (0.02)	.03	0.04 (0.02)	.03
Race/Ethnicity[g]	0.08 (0.16)	.61	0.08 (0.16)	.61	-0.22 (0.20)	.29	-0.22 (0.20)	.29	-0.34 (0.18)	.06	-0.34 (0.18)	.06
Education[h]	0.05 (0.20)	.82	0.05 (0.20)	.82	0.29 (0.25)	.25	0.29 (0.25)	.25	0.57 (0.22)	.01	0.58 (0.22)	.01
Cigarette Dependence[f]	0.00 (0.04)	.96	0.00 (0.04)	.96	0.03 (0.05)	.55	0.03 (0.05)	.55	-0.04 (0.04)	.39	-0.04 (0.04)	.40
Low Depression	-0.44 (0.17)	.01	-0.45 (0.17)	.01	0.39 (0.21)	.06	0.40 (0.21)	.06	0.34 (0.19)	.07	0.42 (0.19)	.03
Elevated Depression	REF		REF		REF		REF		REF		REF	
Pre-First Cigarette Prompt	0.04 (0.02)	.06	0.01 (0.04)	.80	-0.28 (0.02)	<.001	-0.27 (0.04)	<.001	-0.46 (0.03)	<.001	-0.35 (0.05)	<.001
Random Prompts	REF		REF		REF		REF		REF		REF	
Depression Symptom Level × Cigarette Prompt			0.04 (0.04)	.35			-0.01 (0.05)	.79			-0.16 (0.06)	.01
R^{2i}	.10		.10		.12		.12		.18		.18	

Note. [a]Number of Negative Affect prompts: Total 9,600. [b]Number of Positive Affect prompts: Total 10,198. [c]Number of Subjective Cognitive Functioning prompts: Total 5,140. [d]Model 1 provides values for main effects of depression symptoms and prompt type on outcomes. [e]Model 2 provides values for the depression symptom ´

prompt interactions on outcomes. [f]Age and Cigarette Dependence were grand mean centered. [g]Race/Ethnicity coded 0 = Non-Hispanic White, 1 = Other. [h]Education coded 0 = Less than college, 1= At least some college. [i]Parameter estimates and standard errors of the fixed effects of the coefficients. R^2 calculated following (Xu 2003).

Figure 1

Pairwise comparison of depression symptom levels and cigarette prompts on subjective cognitive functioning



Estimated marginal means ± standard error of subjective cognitive functioning prior to the first cigarette of the day and random times throughout the day. *p<.05.